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Provision of club goods in the lab

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Abstract — Club goods (also called toll goods) are collective goods with the possibility of excluding individuals who fail to contribute.The possibility of exclusion from the consumption of the public good has conflicting effects on welfare : on one hand it reduces the incentives to free ride, on the other hand it reduces the number of beneficiaries of the public good. Many clubs require a minimum number of members to be able to provide their activity (e.g., a farmer association, etc.). This step-level component can either be considered as a threshold for the provision of the club good itself, or as a threshold for maintaining some activity within an existing club. While previous experimental research focused on fundraising to provide non-existing public goods, we adopt in this work the second interpretation: the club good already exists and there is a step level for it's maintenance. Aggregate contributions above the threshold constitute an improvement of the club services that benefit only to the club members. The game admits two Nash equilibria: to contribute the provision point and to contribute nothing. The first equilibrium involves a coordination problem. Furthermore, the game involves a social dilemma, since the social optimum is attained if all agents contribute their endowment. Our baseline treatment is a step level public good game with linear payoff above the threshold without money back guarantee. We compare three levels of provision point. Non-contributors are excluded but are informed about the amount of good produced within the club. Our data shows that contributions are significantly higher when exclusion is feasible and when the provision point is low. For the low provision point with exclusion, subjects overcontribute significantly with respect to the threshold and welfare improves. For the high provision point, exclusion lowers contributions and welfare (compared to no-exclusion). Furthermore, we found that exclusion stabilizes contribution over time. The unravelling of contributions in the baseline treatments does not show up in treatments with exclusion.Club goods (also called toll goods) are collective goods with the possibility of excluding individuals who fail to contribute.The possibility of exclusion from the consumption of the public good has conflicting effects on welfare: on one hand it reduces the incentives to free ride, on the other hand it reduces the number of beneficiaries of the public good. Many clubs require a minimum number of members to be able to provide their activity (e.g., a farmer association, etc.). This step-level component can either be considered as a threshold for the provision of the club good itself, or as a threshold for maintaining some activity within an existing club. While previous experimental research focused on fundraising to provide non-existing public goods, we adopt in this work the second interpretation: the club good already exists and there is a step level for it's maintenance. Aggregate contributions above the threshold constitute an improvement of the club services that benefit only to the club members. The game admits two Nash equilibria: to contribute the provision point and to contribute nothing. The first equilibrium involves a coordination problem. Furthermore, the game involves a social dilemma, since the social optimum is attained if all agents contribute their endowment. Our baseline treatment is a step level public good game with linear payoff above the threshold without money back guarantee. We compare three levels of provision point. Non-contributors are excluded but are informed about the amount of good produced within the club. Our data shows that contributions are significantly higher when exclusion is feasible and when the provision point is low. For the low provision point with exclusion, subjects overcontribute significantly with respect to the threshold and welfare improves. For the high provision point, exclusion lowers contributions and welfare (compared to no-exclusion). Furthermore, we found that exclusion stabilizes contribution over time. The unravelling of contributions in the baseline treatments does not show up in treatments with exclusion.

Introduction

The issue of public goods provision has received considerable attention by experimentalists. Most research was concerned with the case of pure public goods even though this is not the most relevant case in practice. Recently, a growing literature has started to investigate impure public goods by taking into account the possibility of exclusion. Different exclusion mechanisms have been examined so far. They are implemented in three ways: (i) a voting procedure (Gary and Chun-Lei, 2006; Margreiter, 2004), (ii) an institutional rule, such as an endogenous threshold (Kocher et al., 2005), granting power to a leader (Levati et al., 2007), a serial cost share mechanism (Gailmard and Palfrey, 2005), or excluding the lowest contributors (Croson et al., 2006), or (iii) a selection rule implemented by the experimenter himself, to sort out types of contributors (Gunnthorsdottir et al., 2000).

In this research, we investigate another possibility of exclusion by means of club goods. Club goods (also called toll goods) are voluntary groups of individuals who derive mutual benefit from sharing at least one of the following: production costs, the members' characteristics or a good characterized by excludable benefits. (Cornes and Sandler, 1996). Among these features, voluntarism is an essential condition. "First, privately owned and operated clubs must be voluntary; members choose to belong because they anticipate a net benefit." (Sandler and Tschirhart, 1997). With the club goods, the Marginal Rate of Substitution between the private and the collective good (MRS) cannot be negative because of the right of the costless exit. The club is rejectable. An individual who does not obtain a net positive benefit from his contribution can choose not to partake (Ng, 1973). On the contrary, in a public good setting, an individual cannot exclude himself from the consumption of the public good. He undergoes the public good. (e.g.: a pacifist has to "consume" the defense policy entirely).

Voluntary adhesion to a club good can be framed as a public good with an individual option to exit. A seminal experiment[1] based on such a mechanism was run by Swope (2002). He explored voluntary adhesion with a Voluntary Contribution Mechanism (VCM) in a linear public good game. A minimum individual amount of contribution was required for an individual to benefit from the club good. By introducing voluntary adhesion in a linear public good, the n-player prisoner's dilemma game is transformed into an n-player coordination game -a linear public good with minimum individual contribution-. Therefore, a subject's task in the baseline treatment (standard VCM) was different from his task in the test treatment (voluntary adhesion). As a result, the observed differences in the distribution of contributions can be attributed both to task differences and to exclusion per se. Furthermore, Swope (2002) mixes two forms of contributions: a fee and free amounts. Therefore, the design fails to isolate the voluntary adhesion effect. The aim of our research is to examine voluntary adhesion in relation to the size property of club goods. In order to provide their activity, many clubs require a minimum number of members (e.g. an association). Such minimum size is critical for a club's existence, and for maintaining a critical level of activity within an existing club. In both cases, either the club or its activity breaks down below this size. However, above the critical size, clubs can improve their services or their capacity (an association offers wider services, a swimming pool open longer).

The provision of such club goods can be framed as a step level mechanism whereby group contributions are required to meet a threshold in order to provide the club. Below the threshold, the club good fails to exist. Several experiments relied on the step level mechanism to study fundraising and charitable giving. (Croson and Marks, 2001; List and Rondeau, 2003; Marks and Croson, 1998; Rondeau et al., 2005; Rose et al., 2002) In our experiment, this step-level mechanism will be interpreted as the minimum size of the club. In addition, we dot allow for rebates beyond the target (Marks and Croson, 1998) but, rather we assume linear provision of the club good above the threshold. The existence of a minimum size raises the question of what happens when the group contribution does not meet the threshold. Fundraising experiments allowed for refund, providing thereby incentives for subjects to increase their contribution. This is not relevant in our case. In reality, an individual cannot recover – or with difficulty –the time or money spent when the club fails to exist (e.g. an investor looses his investment when the firm gets bankrupt). Therefore contributions are lost when the club fails to exist.

[1] Orbell and Dawes (1986) conducted an experiment with the option to adhere or not to prisoner dilemma game. They did not focus on the provision issue.

in addition to capture the size feature of club goods, the step-level component, permits the investigation of voluntary adhesion within two coordination games. Therefore, it rules out the heterogeneous setting of Swope's (2002) experiment. Besides, we suppressed the fee in our experiment. Therefore, we focus on a single form of contribution to the club good. Three levels of the threshold are compared in our experiment: low, medium and high. While the low threshold requires only one player for providing the club, two are required in the medium case, and three are required in the high threshold case.

Our experimental findings show that voluntary adhesion raises significantly group contributions, the success rate of provision and the groups' welfare (except for the high threshold). Voluntary adhesion also increases the number of contributors, moderates cheap riding and sustains longer group contributions over time.

The following section of this paper presents a model of voluntary adhesion to a club good and the theoretical predictions. Section 3 presents the experimental design and section 4 provides a discussion about our conjectures. Section 5 presents the results of the experiment. Section 6 discusses a possible explanation for our findings. The last section is a conclusion.

Theory

Let G be the amount of club good provided, x_i agent i's private good consumption, and w_i his endowment. We assume that agent i's utility is linear. Let us note $g_i = w_i - x_i$ agent i's contribution to the club good (with $w_i > 0$). Thus, $\frac{\partial U}{\partial xi}>0$, $\frac{\partial U}{\partial gi}>0$ and $\frac{\partial^2 U}{\partial^2 xi}=0$, $\frac{\partial^2 U}{\partial^2 gi}=0$. Agent i faces an exclusion mechanism, λ_i. If he contributes to the provision of the club good, i.e. $g_i > 0$, $\lambda_i = 1$, and $\lambda_i = 0$ otherwise. When agent i becomes a member of the club his utility is $U(x_i, G)$, while $U(w_i, 0)$ applies if he stays outside the club. Obviously, agent i chooses to become a member if $U(x_i, G) > U(w_i, 0)$. The existence of the club good is bound to a threshold level of provision T: $G = 0$ if $\sum_{i=1}^{n} g_i < \mathrm{T}$ and $G=\sum_{i=1}^{n} g_i$ otherwise. T is common knowledge. If the threshold is not met, contributions are lost, i.e. there is no Money Back Guarantee mechanism. Finally, beyond the threshold, the club good is provided linearly. It is the improvement of the club. Agent i faces a social dilemma towards this improvement; the marginal return of the club good β is inferior to the marginal return of the private good α_i but $n\beta$ is larger than α_i, where n is the number of contributors ($0<n<N$). In our experimental setting, we consider the symmetric case, where $\alpha_i = \alpha$, and $w_i = w$ for all i.

$$U_i(g_i, G) = \alpha(w - g_i) + \lambda_i \beta G \qquad \text{if } G \geq T$$
$$U_i(g_i, G) = \alpha(w - g_i) \qquad \text{else}$$

$$\text{with } \lambda_i = 1 \text{ if } g_i > 0$$
$$\lambda_i = 0 \text{ if } g_i = 0$$

$$\alpha > \beta \,;\, \alpha < n\beta$$

The contribution game admits multiple Nash equilibria, but only two Nash equilibria in aggregate contributions: $G = T$ and $G = 0$. In the case where $G = T$ all vectors of contributions for which $\sum_{i=1}^{n} g_i = T$ with $g_i \leq \beta T$ and $g_i > 0$ are possible[2] equilibria. In the symmetric case, the equilibrium where $G = T$ Pareto-dominates the equilibrium where $G = 0$. Agent i chooses g_i as a best reply to the expected amount contributed by other players, g_{-i}. The multiple non pareto-ranked Nash equilibria differ with respect to the cost-sharing rule in providing the step-level good. In contrast to the standard linear public

[2] Depending on the choice of parameters. Section 2 *(Experimental design)* details the Nash equilibria of each level of threshold.

good game, the step level good involves coordination issue and cheap riding as opposed to free riding. However, the Pareto dominated equilibrium does not involve a coordination issue. It is a best reply for player i to choose $g_i = 0$ if he expects that $g_{-i} = 0$.

$$UI = -\alpha + \beta \quad \text{if} \sum_1^n g_i = T \text{ and } g_i > 0 \tag{1}$$

The group optimum is achieved whenever all players contribute their endowment to the club good since $n\beta > \alpha$. A player has no incentive to contribute more than the Nash equilibrium because $\alpha > \beta$: the marginal return of one unit from the private good is superior to the marginal return of one unit from the club good (Equation 1). Since agents who do not contribute to the club good are excluded, contributing 0 no longer constitutes the free riding strategy. Instead, the player contributes the minimum unit in order to become a member of the club. Such behavior corresponds to "free riding" in the context of the provision of a club good: contribute, but the least possible amount, in order to benefit from the club. In our experiment, subjects allocate integer amounts. Therefore, the minimum contribution level is 1 token.

Experimental design

The baseline treatment is a linear public good game with a threshold. Each subject i has an initial endowment of $w = 20$ tokens that he can allocate (in integer amounts) between a private account and a collective account. The private account yields a marginal return $\alpha = 1$ per token invested. The collective account provides a marginal return $\beta = 0.5$ per token invested if the target T is met. If the target level is not met, subject's contributions are lost. If the group contributions are above the threshold, each contributor enjoys the total amount of the club good provided. We compare three levels of threshold: Low threshold (15 tokens), medium threshold (30 tokens) and high threshold (60 tokens). In the first case, a single subject can provide the club good, in the second one at least two subjects are required to reach the threshold and in the high threshold three members of the group are required to reach the 60 tokens. Note that, since we are considering a step level continuously provided above the threshold and that subjects homogenously value the provision of the club good, the step return does not vary between the thresholds (Croson and Marks, 2000). As a consequence, we are comparing the different thresholds within a homogenous return setting. Table I summarizes parameters of the experiment.

We compare the baseline treatment to the voluntary adhesion treatment. Treatments allowing for voluntary adhesion follow the same baseline design with a minor change: subjects are excluded from the benefit of the club good if they fail to contribute. Since we expect that voluntary adhesion can affect the level of contribution, careful attention was given to the instructions in order to prevent any design effect on contributions. Instructions were written in a neutral way, avoiding words like "investment" or "contributions". Instead we chose words like "put", "budget" and "account".

The experiment was run at the University of Montpellier I, with a large subject pool of volunteers from various disciplines: economics, law, art, psychology, literature, medicine, engineering, and sport. Care was taken to ensure that no subject participated in more than one session. 352 students participated to our experiment. The experiment was programmed and conducted with the software z-Tree (Fischbacher, 2007). Upon attending the experimental lab, the 16 participants of each session were randomly assigned to groups of 4 players in a partner design. A public reading of the instructions followed a private one in order to make the rules of the game common knowledge. Subjects had to make tow decisions: how many tokens to invest in their private account and how many tokens to invest in the collective account. The history of the past interactions was available for each subject at any time during the experiment. The constituent game was repeated 25 periods. Accumulated point earnings over the 25 periods were converted into Euros at the end of the experiment at a publicly announced rate.

Table I. Experimental parameter.

Treatment	Threshold		Required contributors [a]	Number of groups	Step return [b]	MBG [c]
Baseline	Low	15	1	6	2	No
	Medium	30	2	5	2	No
	High	60	3	4	2	No
Voluntary adhesion	Low	15	1	8	2	No
	Medium	30	2	6	2	No
	High	60	3	4	2	No

(a) Number of contributors required to reach the threshold; (b) Benefit /cost = $\frac{n\beta T}{T}$; (c) Money Back Guarantee.

For the high threshold, all contribution vectors that reach exactly the threshold are Nash equilibria. A player invests collectively whenever he predicts that the other members of his group will contribute at least 40 tokens. (15, 15, 15, 15) is therefore a symmetrical equilibrium (*gi = T/n*) around which a group of non-communicating people might be expected to coalesce. The contribution vector (1, 20, 20, 19) constitutes a Nash equilibrium that maximizes player's 1 Nash benefits. It yields 49 points. Player 2 and player 3 earn the minimum Nash benefits when a club good is provided, 30 points. The contribution vector (0, 20, 20, 20) is the equivalent vector maximizing Nash earning for player 1 in the public good case (50 points).

Again, for the low threshold, all contribution vectors equalling 15 tokens do not constitute Nash equilibria. A player contributes to the collective account when other members of the group invest at least 8 tokens. The minimum Nash earning for a player is obtained when he contributes 7 tokens to the collective account. It yields 20.5 points – when the step level good is provided -. The maximum Nash earning is obtained when other members of the group invest 14 tokens (15 tokens for the baseline) and the player contributes 1 token (0 token for the baseline). It yields 26.5 points in the voluntary adhesion treatment and 27.5 points in the baseline treatment.

Conjectures

For the baseline and the voluntary adhesion treatment, the Nash prediction for selfish players is that the group contribution is either equal to the threshold level or to zero contributions. Since zero contribution is Pareto dominated by the threshold Nash equilibria, we expect that subjects will coordinate on the threshold in both treatments. Moreover, since the threshold is common knowledge the symmetrical equilibrium constitutes a focal point (Schelling, 1980). Our first conjecture is thus:

Conjecture 1: Groups coordinate on the symmetric Pareto dominant Nash equilibrium in the baseline and in the voluntary adhesion treatments

Increasing the threshold affects the risk associated with strategies consistent with the Pareto dominant equilibrium. Since larger contributions are required to reach the threshold, higher potential losses are involved because of the no refund rule. Thus, with a higher threshold, subjects might become more reluctant to contribute. This is known as the *assurance problem hypothesis* (Isaac et al., 1989). However, a higher threshold yields also larger benefits. In our setting the reward of provision is correlated to the threshold level: 7.5 points in the low threshold, 15 points for the medium and 30 points for the high threshold. The subject contributes more but earns more from the collective good. Hence, the threshold is likely to lead to larger contributions by subjects. Summarizing, there are two opposite effects when the threshold is increased: the assurance problem becomes more dramatic, leading to lower contributions, the reward of the club becomes larger leading to higher contributions.

Earlier experiments provide mixed evidence about these effects. Rapoport and Suleiman (1993) showed that the threshold has no effect on contributions when random endowments are assigned to subjects. Cadsby and Maynes (1999) found that contributions decline with the threshold level with a constant reward and no rebates setting. The main finding however, is a tendency for contributions to increase (decrease) with the threshold at low (high) threshold levels (Bougherara *et al.*, 2007; Dawes *et al.*, 1986; Isaac *et al.*, 1989; Suleiman and Rapoport, 1992). These findings are consistent with the fact that the assurance problem effect becomes relatively stronger for high threshold levels while the "earning effect" is relatively stronger for low threshold levels. Therefore, as the threshold increases, individuals first increase their contribution up to some level of the threshold where they move in the opposite direction, with a switching point that varies according to the individual's preferences.

Conjecture 2: Increasing the threshold from the low to the medium threshold increases group contributions. Increasing the threshold form the medium to the high level decreases contributions

Introducing voluntary adhesion excludes contribution vectors where players invest 0 tokens. As a consequence, the number of possible equilibrium contribution vectors is lower in the voluntary adhesion treatment than in the baseline. Actually the set of equilibria under voluntary adhesion is included in the larger set of equilibria of the baseline treatment. As a result, a subject's expectation about others' contributions is affected: less uncertainty is involved and so there are fewer possibilities for coordination failure. The problem faced by our player is close to the tacit coordination experiment of Van Huyck *et al.* (1990) but in a context of non-Pareto ranked equilibria.

Furthermore, when all subjects of the group decide to adhere to the club i.e. 4 tokens contributed, subjects are guaranteed that at least 26.66% of the Nash equilibrium will be provided in the low threshold, 13.33% in the medium threshold and 6.66% in the high threshold. In contrast, subjects' expectations in the baseline treatment do not involve such guarantee in reaching the threshold. Thus, voluntary adhesion reduces the strategic uncertainty of the coordination task.

Conjecture 3 : Voluntary adhesion increases the success of provision

The voluntary adhesion prediction differs from the baseline prediction by the exclusion of the contribution vectors where one or more players contribute 0 token. Therefore, the number of players in the voluntary adhesion equilibrium is always equal to 4 players. In the baseline treatment, contribution vectors with 2 or 3 players free ride[5] are possible Nash equilibria.

Conjecture 4: Voluntary adhesion increases the number of contributors.

In the next section, we present the results of our experiment with respect to these conjectures.

Results

We report in Table II the general pattern of the results. It depicts by treatment (baseline and voluntary adhesion) and for each threshold (low, medium and high) the individual and the group level of contribution, the success rate of provision and the welfare. The success rate of provision is the percentage of success of provision of the step-level good. It is equal to the number of times group contributions reach at least the threshold divided by the number of periods. Hereafter, we will call the success rate of provision simply "success rate". The welfare is equal to the final monetary payment of the subjects.

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5 Contribution vectors for which the group contribution is equal to the threshold and for which two or three players free-ride are not necessarily Nash equilibria. In the medium threshold, there exists only one equilibrium contribution vector where exactly two players free ride (15, 15, 0, 0). The contribution vectors (16, 14, 0, 0), (17, 13, 0, 0), (18, 12, 0, 0), (19, 11, 0, 0) and (20, 10, 0, 0) are not equilibria because player 1 is always better off if he deviates (a similar arguments holds for the permutation of these vectors). The same remark holds for the low threshold: (15, 0, 0, 0) , (14, 1, 0 , 0), (13, 2, 0 , 0), (12, 3, 0 , 0) , (11, 4, 0 , 0), (10, 5, 0 , 0), (9, 6, 0 , 0), (8, 7, 0 , 0) are not Nash equilibrium vectors. For the high threshold, all vectors for which the agregate contribution is equal to the threshold are Nash equilibria. One player can free ride in the high threshold, i.e. is for the contribution vector (20, 20, 20, 0) and permutations of it.

The econometric analysis conducted in this section follow this scheme. First, we compare the baseline treatment and the voluntary adhesion treatment using non-parametric tests: a two-sided Wilcoxon-Mann-Whitney test or a two-sided χ^2 test depending on the variable (qualitative or quantitative). Then, we control for the differences between the two treatments with a GLS panel[6] data regression with random effects[7]. The dependent variable is defined specifically for each analysis. When it is a binary variable, e.g. success of provision, we run a logit regression on panel data. Unless reported otherwise, the regressors are a dummy treatment taking value 1 for the voluntary adhesion (0 for the baseline) and a time variable. They are denoted *Voluntary adhesion* and *Period*. We correct for heteroskedasticity and auto-correlation each time it was detected[8]. We conclude for a significant statistical effect when both the non-parametric tests and the panel data regression agree. Finally, the rejection threshold of the null hypothesis is at 5%.

Table II. Descriptive statistics.

	Average individual contribution [(a)] (SD)		Average group contributions (SD)		Success rate of provision [(b)]		Welfare [(c)] (SD)	
	Baseline	*Voluntary adhesion*	*Baseline*	*Voluntary adhesion*	*Baseline*	*Voluntary adhesion*	*Baseline*	*Voluntary adhesion*
Low (T=15)	3.95 (6.48)	5.78 (5.68)	15.82 (19.13)	23.14 (15.64)	41.3%	73.5%	573.25 (109.13)	617.87 (101.52)
Medium (T=30)	6.44 (6.67)	7.83 (5.89)	25.79 (17.88)	31.35 (14.26)	39.7%	67.7%	558.48 (80.60)	626.4 (101.09)
High (T=60)	8.21 (8.23)	7.15 (8.22)	32.87 (29.09)	28.6 (26.13)	39.0%	30.0%	606.56 (188.86)	548.47 (180.02)

(a) The symmetrical equilibrium is 3.75 for the low threshold, 7.5 for the medium threshold and 15 tokens for the high threshold.
(b) Success rate = Number of times groups reach the threshold / Number of periods.
(c) Welfare = Total points accumulated at the end of the experiment. (1 token in the private account = 1 point ; 1 token in the collective account = 0.5 point).

Result 1: Mixed results are observed for the Nash prediction. Neither the baseline nor the voluntary adhesion are better described by the Pareto dominant equilibrium

Conjecture 1 states that groups will play the symmetrical Pareto dominant Nash equilibrium. To examine this conjecture, we report in Table III the percentage of Nash equilibria in each treatment. It is equal to the number of times group contributions reach exactly the threshold divided by the number of times group contributions reach at least the threshold (*Cf.* Section 3 *Experimental design* for the vector of contribution constituting a Nash equilibrium) Clearly, groups coordinate few times on the threshold. We perform a two-sided [9] Student test (T test) to compare group contributions in each threshold and in each treatment to the threshold level. If the prediction was verified, we have checked if players opted for a symmetrical strategy as a solution of coordination on the threshold [10]. The T test shows that in the low threshold, group contributions

6 We check the presence of unobserved individual heterogeneity with a Breusch and Pagan LM test before each panel data regression. The tests confirm the significant presence of individual effects and thus the relevance of the data as a panel structure.
7 Random effects were preferred over fixed effects for two reasons: first, they allow for regressors that do not vary over time (dummy variable) and second, the GLS estimator corrects for multiple observations from a single group of subjects (Greene, 2003)
8 For all regressions we check for the existence of auto-correlation and heteroskedasticity : If only heteroskedasticity was detected (White test) we correct by running FGLS with a variance covariance matrix of the errors allowing for heteroskedasticity. If only intra-individual autocorrelation (Breusch and Pagan LM test) or inter-individual autocorrelation was detected (Wooldridge test) or both simultaneously, we correct by a GLS random effects regression with a Durban-Watson coefficient. Finally, if both heteroskedasticity and any form of auto-correlation was detected, we correct by running a FGLS with a modified matrix of covariance of the errors allowing for autocorrelation and heteroskedasticity. See for a discussion of hetroskedasticity and autocorrelation under panel data. (Baltagi, 1995)
9 If the two-sided T test shows that the group contributions is not equal to the Nash equilibrium, we conduct a one sided T test to determine if group contributions is significantly lower or higher than the Nash equilibrium.
10 We run a two-sided T test to compare individual contribution to 3.75 tokens in the low threshold, 7.5 tokens in the medium and

in the baseline treatment are significantly equal to 15 tokens (t=0.52; p=0.59) and subjects coordinate around the symmetrical equilibrium (t=0.52 ; p=0.59). However, for the voluntary adhesion treatment, group contributions are significantly higher than the Nash equilibrium (t=7.35; p<0.01). For the medium threshold, group contributions are significantly lower than the Nash equilibrium in the baseline treatment (t=-2.89; p<0.01) and are significant equal in the voluntary adhesion treatment (t=1.05; p=0.29). Again, subjects do coordinate around the symmetrical Nash equilibrium (t=1.28; p=0.09). Lastly, in the high threshold, Nash prediction is not significant for both treatments: the baseline treatment (t=-9.32; p<0.01) and the voluntary adhesion (t=-12.01; p<0.01). Hence, mixed results are found when we compare group contributions to the Nash prediction. Neither the baseline nor the voluntary adhesion is better predicted by the Nash equilibrium. However, in both treatments when subjects coordinate on the threshold the symmetrical solution is selected. Conjecture 1 is therefore partially confirmed.

Table III. Percentage of Nash equilibria per treatment[(a)].

	Baseline	Voluntary adhesion
Low (T=15)	4.6 %	6.0%
Medium (T=30)	1.9%	4.8%
High (T=60)	4%	9%

[(a)] Percentage of Nash equilibria = Number of Nash equilibria[11] / Number of times group contributions reach at least the threshold.

Result 2: Increasing the threshold from the low to the medium threshold increases significantly group contributions. However, contributions remain significantly unchanged from the medium to the high threshold

Conjecture 2 states an increase of contributions from the low to the medium threshold and a decrease of contributions from the medium to the high threshold. We first examine the group contributions. Then, we address the success of provision. We conduct a Mann-Whitney Wilcoxon[12] test to compare the increase of group contributions from the low to the medium threshold and from the medium to the high threshold. We perform these tests separately for the baseline and for the voluntary adhesion treatment. The test shows that there is a significant increase from the low threshold to the medium threshold in the baseline (U=-5.37; p<0.01) and in the voluntary adhesion treatment (U=-5.41; p<0.01). However, there is no difference between group contributions of the medium and the high threshold in the baseline (U= -1.40; p=0.15) or in the voluntary adhesion treatment (U=1.24; p=0.21). We then conduct a panel data regression with group contributions as the dependent variable. The regressors are a threshold dummy variable and time. We interpret our results with respect to the low threshold. The regression is conducted separately for the baseline and for the voluntary adhesion treatment. We report results in Table IV. It outlines that the increase of group contributions from the low to the medium threshold is significant whereas from the low to the high is not significant. This finding is observed for the baseline and the voluntary adhesion treatment. Thus, the regression confirms the U test. Mixed evidences are therefore observed for conjecture 2. The increase of contributions[13] from the low to the medium threshold is significant but contributions do not drop from the medium to high. Contributions in the high threshold remain equal to contributions of the medium threshold.

15 tokens in the high.

11 *Cf. Experimental design.*

12 Hereafter we will call the Mann-Whitney Wilcoxon test the U test.

13 We also examined the variation of the success rate with respect to the threshold level. Results are reported in Appendix 2.1.. In the baseline treatment, there is no significant difference of the success rate between the three levels of threshold. In the voluntary adhesion treatment, there is only a significant decrease of the success rate from the medium to the high threshold. Thus, in comparison to group contributions, the success rate seems little correlated to the threshold level (except for the voluntary adhesion treatment previously pointed out).

Table IV. Results from panel data regression explaining group contributions in the pooled sample (Low + Medium + High threshold) [(a)].

Regressors	Baseline	Voluntary adhesion
Intercept	23.79 (*) (9.24)	34.96 (*) (23.78)
Threshold_med [(b)]	13.81 (*) (5.87)	8.04 (*) (3.84)
Threshold_high [(b)]	--	--
Period	- 0.98 (*) (-7.54)	-0.90 (*) (-9.46)
Log likelihood	-1404	-1466
Number of observation	400	425
Number of groups	16	17
Time periods	25	25

*): significant at 1% level; (**): significant at 5% level; (***): significant at 10% level; -- non significant; (a) T-statistics are in parentheses; (b) The low threshold dummy variable is dropped; Regressions are corrected for heteroskedasticity and autocorrelation.

Result 3: Voluntary adhesion significantly increases group contributions, success of provision and welfare, except for the high threshold

Figures 1, 2 and 3 depict the evolution of group contributions over time. A visual inspection shows that voluntary adhesion increases group contributions in the low threshold and in the medium one. There is no clear effect for the high threshold: Average group contributions in the voluntary adhesion treatment are lower than average group contributions in the baseline treatment during the main part of the game (until the period 17). However, it rises during the 8 last periods and becomes higher than Average group contributions of the baseline treatment. Hereafter, we first wonder about the statistical significance of this graphical interpretation. Then about its consequences on the related outcomes: the success of provision and the welfare.

Starting this analysis with the variable group contributions, the U test shows that group contributions is significantly higher in the voluntary adhesion treatment for the low threshold ($U=-5.71$; $p<0.01$) and for the medium threshold ($U=-3.32$; $p<0.01$). In the high threshold, group contributions do not change between the two treatments ($U=1.27$; $p=0,20$). Then, we run the panel data regression. We explain group contributions –the dependent variable- by a dummy treatment V*oluntary adhesion* and we control for learning by introducing time with the variable period*.* V*oluntary adhesion* and *Period* are our regressors. A significant dummy regressor *Voluntary adhesion* indicates a significant increase – or decrease - of the group contributions. A significant regressor *Period* points out if the increase/decrease of the group contributions is stable or varies over time. Table V reports the results of the regression. It reveals that group contributions significantly increase in the low and the medium threshold but are not affected in the high threshold, thus confirming the U test results.

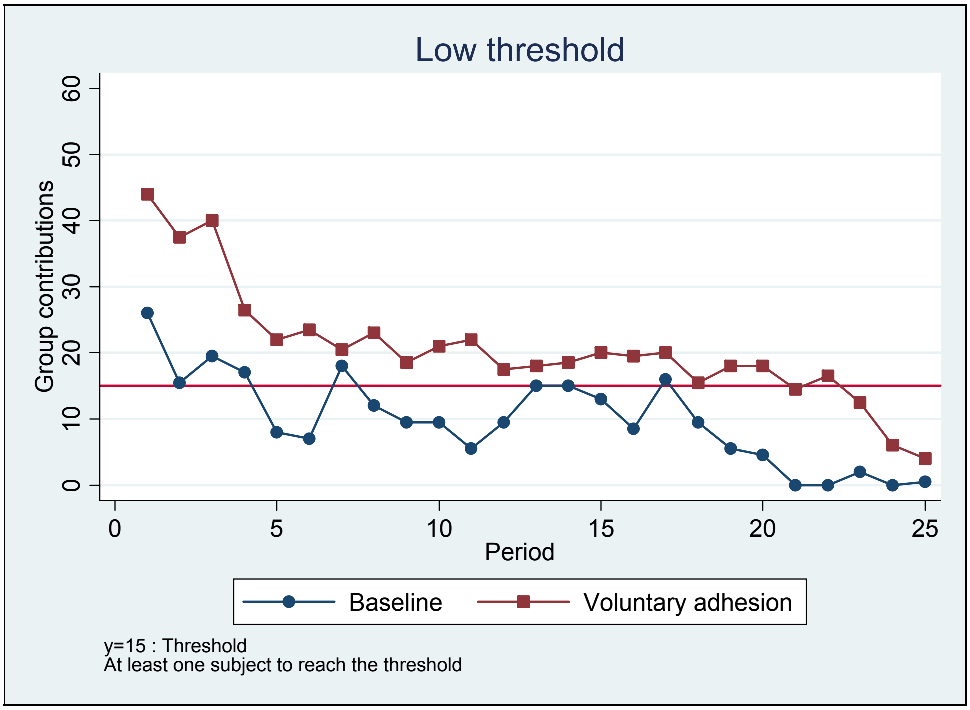

Figure 1. Median group contributions (T=15)[15].

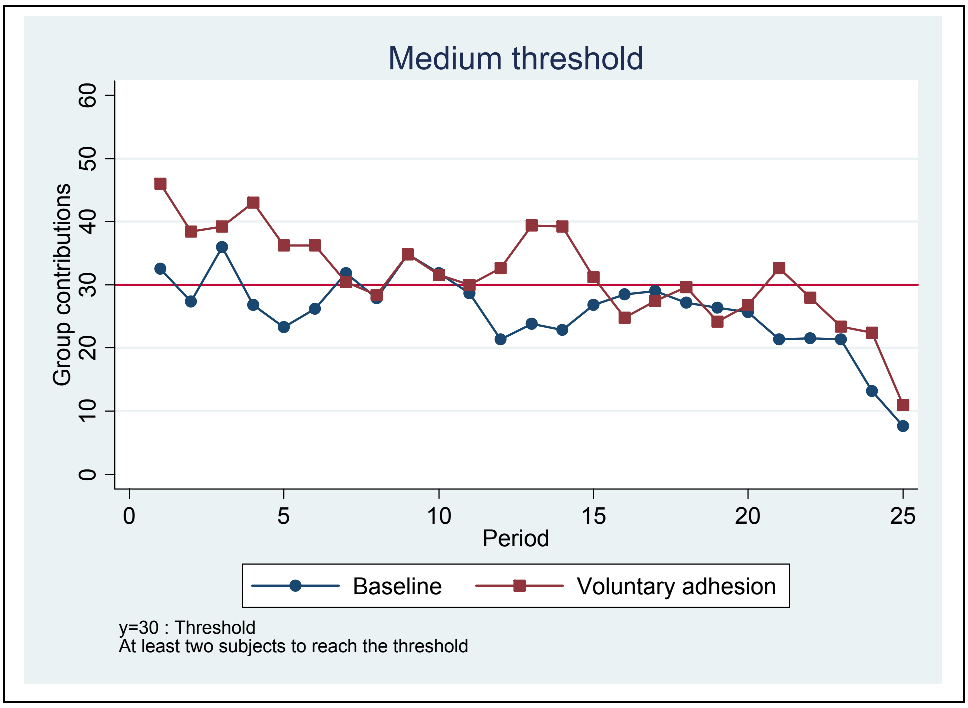

Figure 2. Average group contributions (T=30).

15 We display the median group contributions instead of the average group contributions because of the high level of group contributions in the baseline for one group at the beginning of the experiment that distort average contributions.

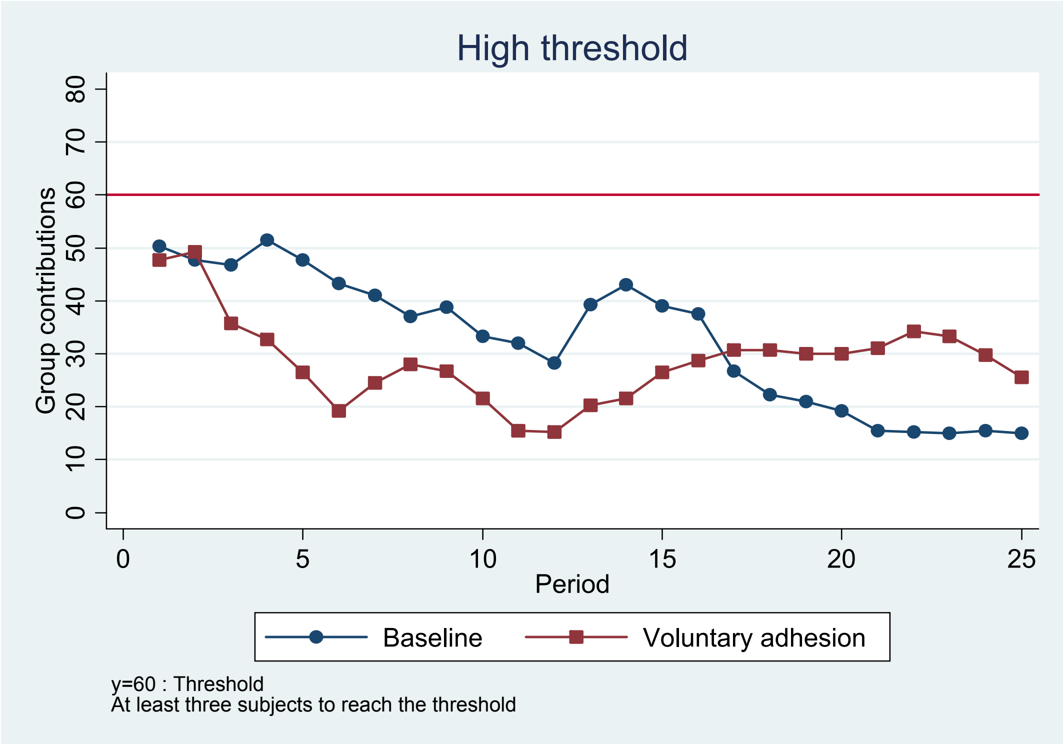

Figure 3. Average group contributions (T=60).

Table V. Results from panel data regression explaining group contributions for each level of threshold [(a)].

Regressors	T=15	T=30	T=60
Intercept	25.01 (*) (18.82)	37.52 (*) (18.93)	36.40 (*) (4.19)
Voluntary adhesion	10.20 (*) (7.55)	6.58 (*) (3.42)	--
Period	- 0.88 (*) (-13.34)	-1.00 (*) (-8.34)	-0.97(*) (-3.55)
Log likelihood	-1118	-978	-643
Number of observation	350	275	200
Number of groups	14	11	8
Time periods	25	25	25

(*): significant at 1% level; (**): significant at 5% level; (***): significant at 10% level; -- non significant; (a): T-statistics are in parentheses ; Regressions are corrected for heteroskedasticity and autocorrelation.

Next, we perform the same analysis with the success of provision. The success is a binary variable taking value 1 when group contributions reach at least the threshold and 0 when it is lower than the threshold. We recall that the success rate is the percentage of the success of provision of the step-level good. Table II outlines that the success of provision increases from the baseline to the voluntary adhesion treatment by 32.2% in the low threshold and by 28.0% in the medium threshold. In the high threshold, it decreases by 9.0%. A Chi2 test shows that voluntary adhesion increases significantly the success rate for the low threshold (χ^2=36.86; p<0.01) and for the medium threshold. (χ^2=22.33; p<0.01). In the high threshold, there is no significant change between the two treatments (χ^2=1.79; p=0.18). We then run a logit regression with random effects. Success, the binary variable, is the dependent variable. The regressors are V*oluntary adhesion* and *Period*. Table VI reports the output of the regression. It indicates that the significant sign of V*oluntary adhesion* is positive meaning that there is an increase of the success of provision in the voluntary adhesion. Table VI also indicates that the success of provision declines over time since the sign of *Period* is negative. Hence, the regression confirms the results of the statistical test.

Table VI. Results from panel data regression explaining success of provision for each level of threshold [(a)].

Regressors	**T=15**	**T=30**	**T=60**
Intercept	1.34 (***) (1.74)	--	--
Voluntary adhesion	2.36 (*) (2.36)	1.45 (**) (2.25)	--
Period	-0.15 (*) (-6.35)	-0.07 (*) (-3.66)	--
Log likelihood	-153.27	-164.78	--
Number of observation	350	275	200
Number of groups	14	11	8
Time periods	25	25	25

(*): significant at 1% level; (**): significant at 5% level; (***): significant at 10% level; -- non significant; (a): T-statistics are in parentheses ; Regressions are corrected for heteroskedasticity and autocorrelation.

Table VII. Results from panel data regression explaining welfare for each level of threshold [(a)].

Regressors	**T=15**	**T=30**	**T=60**
Intercept	96.54 (*) (30.38)	95.54 (*) (28.67)	78.48 (*) (-2.75)
Voluntary adhesion	12.49 (*) (5.07)	9.36 (*) (4.19)	-11,03(*) (2.17)
Period	- 0.83 (*) (-8.90)	-0.95 (*) (-4.56)	0,60(**) (16.65)
Log likelihood	-1286	-1193	-969
Number of observation	350	275	200
Number of groups	14	11	8
Time periods	25	25	25

(*): significant at 1% level; (**) : significant at 5% level; (***): significant at 10% level; -- non significant ; (a) T-statistics are in parentheses ; Regressions are corrected for heteroskedasticity and autocorrelation.

In the baseline treatment when the step level public good is reached, it benefits all the subjects. In the voluntary adhesion treatment, it benefits only the contributors. Does this exclusion of the benefactors have an effect on welfare? To test this proposition, we have considered final monetary payment as an indicator of the welfare difference. With a U test, we compare earnings of the subjects in the baseline and voluntary adhesion treatment. It shows that the increase of the welfare in the voluntary adhesion treatment compared to the baseline is statistically significant for the low ($U=-3.30$; $p=0,00$) and the medium threshold ($U=-2.30$; $p=0.02$). However, welfare in the high threshold is significantly higher in the baseline than in the voluntary adhesion threshold ($U=2.72$; $p<0.01$). Results of the regression explaining welfare – the dependent variable - with the same previous regressors are reported in Table V.

Voluntary adhesion is significant and positive indicating an increase of welfare in the regression of the low and the medium threshold. This finding confirms the statistical U-test and are consistent with the previous increase of the group contributions and the success rate. The panel regression reveals also that the welfare decreases for the high threshold. The statistical U test result is thus confirmed.

Thus, voluntary adhesion increases group contributions, success of provision and welfare when the threshold is low or medium. Conjecture 3 is therefore confirmed for these two levels of threshold. However, for the high threshold level conjecture 3 is not confirmed. See section 6 for a discussion of these findings.

Result 4: Voluntary adhesion increases the number of contributors and decreases cheap riding, except for the high threshold

Hereafter we aim to examine Conjecture 4. Figure 4 depicts the number of contributor per group for each period for the low threshold[16]. Clearly, a visual inspection indicates more contributors per group in the voluntary adhesion treatment than in the baseline. A χ^2 test to comparison shows a significant increase in the low (χ^2 = 153.31; p<0.01) and the medium threshold (χ^2 = 67.28; p<0.01). However, the test reveals no significant difference in the high threshold (χ^2 = 6.26; p=0.18). We run a regression explaining the number of contributors per group in each period. The regressors are *Voluntary adhesion* and *Period*. Table VIII reports the results of the regression. *Voluntary adhesion* is significant and positive in the low and the medium threshold. Voluntary adhesion increases by two players the number of contributors in the low threshold and by one player in the medium threshold. This increase is not significant for the high threshold. The statistical tests are thus confirmed by the regression. Our conjecture 3 is confirmed for the low and the medium threshold but not for the high threshold.

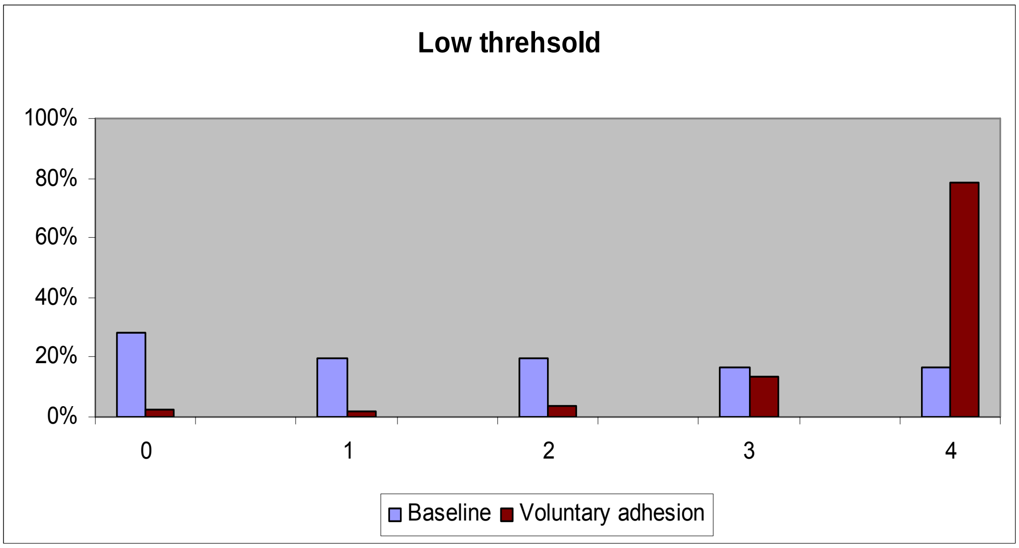

Figure 4. Percentage of contributors per group (T=15).

Is this increase of the number of contributors is accompanied by a decrease of cheap riding[17]? To answer this question we first compare the individual contribution in the baseline and the voluntary adhesion treatment. Then, we compare strictly positive contributed amounts between the two treatments; that is we drop from the observations free riders in the baseline and subjects who excluded themselves in the voluntary adhesion treatment.

The U test shows that subjects contribute significantly more in the voluntary adhesion treatment than in the baseline treatment when consider positive amounts. We observe this increase for the low (U=-12.63 ; p<0.01) and the medium threshold (U=-5.23 ; p<0.01) but not for the high threshold where there is no significant difference (U=0.95 ; p=0.33). When we consider strictly positive amounts, we find that individuals contribute significantly more in the baseline than in the voluntary adhesion treatment. (Low U =5.13 ; p<0.01) and medium U=4.88 ; p<0.01) In the baseline treatment, a few generous individuals

16 See Appendix 2.9. and 2.10. for the medium threshold and 11 and 12 the high thresholds.
17 See appendix 2.13. for the quantiles of individual contributions.

provide the public good whereas in the voluntary adhesion treatment all the subjects provides the club good but with less effort. We report in Table X the results of the regression.[18] We explain individual contribution by the regressors *Voluntary adhesion* and *Period.* Table IX indicates that voluntary adhesion decreases individual contribution by 1.30 tokens in the low threshold, and 1.69 tokens in the medium threshold. It does not have an effect in the high threshold as the U-test already indicated. This result suggests that the increase of the number of contributors is accompanied by a decrease of individual contributions. Subjects seem to coordinate better in the voluntary adhesion treatment.

Table VIII. Results from panel data regressions explaining the number of contributors per group for each level of threshold [a].

Regressors	**T=15**	**T=30**	**T=60**
Intercept	2.03 (*)	2.88 (*)	3.61
	(8.93)	(10.84)	(7.26)
Voluntary adhesion	2.00 (*)	1.06 (*)	--
	(8.93)	(3.77)	
Period	-0.02 (*)	0.02 (*)	-0.12 (*)
	(-4.56)	(-2.72)	(-5.00)
Log likelihood	-217. 71	-369.99	-175.43
Number of observation	350	275	200
Number of groups	14	11	8
Time periods	25	25	25

(*): significant at 1% level; (**): significant at 5% level; (***): significant at 10% level; -- non significant; (a) : T-statistics are in parentheses ; Regressions are corrected for heteroskedasticity and autocorrelation.

Table IX. Results from panel data regression explaining individual contribution for each level of threshold [a].

Regressors	T=15		T=30		T=60	
	Contribution	*Cheap_* [b]	*Contribution*	*Cheap_* [b]	*Contribution*	*Cheap_* [b]
Intercept	4.56 (*)	8.91 (*)	9.09(*)	10.58(*)	14.22(*)	14.57(*)
	(18.92)	(21.00)	(17.83)	(36.35)	(13.79)	(86.76)
Voluntary adhesion	2.89 (*)	- 1.30 (*)	1.84 (*)	-1.69 (**)	-3.63(*)	-1.36(*)
	(14.06)	(-3.18)	(3.99)	(-6.59)	(-3.82)	(-6.00)
Period	-0.17 (*)	-0.15 (*)	-0.21(*)	-0.04 (*)	-0.45(*)	0.04(*)
	(-12.82)	(-8.79)	(-7.41)	(-2.13)	(-7.60)	(3.04)
Log likelihood	-4029	-2949	-3199	-2368	-2293	-1202
Number of observation	1400	989	1100	799	800	433
Number of subjects	56	53	44	44	32	29
Time periods	25	25	25	25	25	25

(*): significant at 1% level; (**): significant at 5% level; (***): significant at 10% level; -- non significant;(a) : T-statistics are in parentheses; (b) : Strictly positive contributions (Free riders and auto-excluded subjects are dropped in each period) ; Regressions are corrected for heteroskedasticity and autocorrelation.

18 The number of the remaining observations is reported at the bottom of the table.
21 Total variance can also be break down to intragroup variance and intergroup variance. See Sevestre (2002) for further discussion.

Result 5: Voluntary adhesion decreases weakly the variance of group contributions.

Do voluntary adhesion affects the variance of group contributions? Let G_{jt} denotes the group contributions. It depends on the group j 1,..,J and on the period t 1,…,T. Equation 2 represents the total variance of group contributions.

$$\sigma_G^2 = \sum_{j=1}^{J} \sum_{t=1}^{T} (G_{jt} - \overline{G}_{jt})^2 \qquad (2)$$

Equation 2 can be broken down as follow:

$$\sigma_G^2 = \sum_{t=1}^{T} \sum_{j=1}^{J} (G_{jt} - \overline{G}_{..})^2 = J\sum_{t=1}^{T} (G_{.t} - \overline{G}_{..})^2 + \sum_{j=1}^{J} \sum_{t=1}^{T} (G_{jt} - \overline{G}_{.t})^2 \qquad (3)$$

The total variance of group contributions is composed by intertemporal variance and intratemporal variance[21]. The first term of the equation 3 represents intertemporal variance. It is the variance of group contributions between periods. It yields 25 observations per treatment. The second one stands for intratemporal variance. It is the variance of group contributions for each period and for each group. It yields 150 observations per treatment (for a treatment with 6 groups).

To compare the intertemporal variance between the baseline and the voluntary adhesion treatment, we run a U test. It shows that voluntary adhesion does not affect the intertemporel variance of group contributions for the low (U=-0.98 ; p=0.32) and the medium threshold (U=-0.99 ; p=0.31). However, it decreases intertemporal variance of the high threshold (U=2.94; p<0.01). We do not have sufficient observations to run a panel data regression in order to confirm this analysis (only 25 observations). In the second case, - intratemporal group contributions variance – the U test shows that it is significant only for the medium threshold (U=3.72; p<0.01). For the low (U= 1.54; p=0.12) and the high threshold (U=0.06; p=0.94) intratemporal variance does not vary. Then, we run a panel data regression with a dependent variable equal to the squared difference between the group contributions for each period and the total average group contributions[22]. The regressors are *Voluntary adhesion* and *Period.* Table X reports the results. *Voluntary adhesion* is negative and significant for the medium threshold and not significant for the low and the high threshold. Thus, the regression confirms the results of the statistical test. On the whole, voluntary adhesion affects the variance of group contributions only for the medium and the high threshold: it decreases the intertemporal variance of the high threshold and the intratemporal variance of the medium threshold. But it does not decrease the total variance of group contributions in any threhsold.

Table X. Results from panel data regression explaining the intratemporal variance of group contributions for each level of threshold [(a)].

Regressors	**T=15**	**T=30**	**T=60**
Intercept	325.12 (*)	142.89 (*)	--
	(7.18)	(3.25)	
Voluntary adhesion	--	-101.65 (*)	--
		(-2.64)	
Period	-10.09 (*)	6.24 (*)	19.23
	(-4.59)	(2.68)	(2.33)
Log likelihood	-2143	-1817	-1376
Number of observation	350	275	200
Number of groups	14	11	8
Time periods	25	25	25

(*): significant at 1% level; (**): significant at 5% level; (***): significant at 10% level; -- non significant; (a): T-statistics are in parentheses ; Regressions are corrected for heteroskedasticity and autocorrelation.

22 Total average group contributions = $\frac{\sum_{t=1}^{T}\sum_{j=1}^{J} G_{jt}}{JT}$; t stands for the number of periods t=1,…,T and j for the number of groups per treatment j=1,…,J.

Result 6: Voluntary adhesion raises the asymptotic group contributions in the low and the medium threshold

We aim to examine the convergence of group contributions. Do group contributions in the baseline treatment converge to the same level of group contributions in the voluntary adhesion treatment ? Do group contributions converge to the Nash equilibrium ? We carry out the following regression (Equation 4). It is inspired from Camera *et al.* (2003). We explain group contributions G_{jt} (the dependent variable) by an inverse function of time *1/t* (the regressor) where *j* stands for groups of players, *t* for time u_j for the group effect and ε_{jt} for the error term.

$$G_{jt} = G_{\infty} + G_0 \frac{1}{t} + u_j + \varepsilon_{jt} \qquad (4)$$

where $j = 1, 2,.., J$ and $t = 1, 2,.., 25$

As *t* becomes large, *1/t* gets negligible. Thus, the intercept, $G\infty$ represents the asymptotic group contributions. At the opposite, $G\infty + G_0$ represents the group contributions at the initial period. We report in Table XI the results of the regression. Clearly, all the intercepts are different indicating a different level of asymptotic group contributions between the public good and the club good. Table XI also points out a higher intercept for the voluntary adhesion treatment in the low (+6.84 tokens) and the medium threshold (+8.15 tokens) but a lower one for the high threshold (-2.08 tokens). Finally, the regression indicates that none of the treatments converge toward the Nash equilibrium except for the medium threshold in the voluntary adhesion treatment.

We further our analysis by examining more specifically convergence toward the threshold. We conducted a similar analysis to that of Marks and Croson (1998). We calculate the squared distance of the threshold of each group for each period. It is our dependant variable. We explain this difference by a non-linear function of time *Period + Period_squared*. A negative significant coefficient of the regressor *Period* means the existence of a convergence to the threshold while a significant positive sign means the existence of a divergence from the threshold. In addition, a significant coefficient of *Period_squared* means that the convergence/divergence is non linear. Table XII outlines the result of the regression per treatment. *Period* is significant for all the voluntary adhesion treatments. It is negative for the low and the medium threshold - indicating a convergence to the Nash equilbrium - and positive for the high threshold –indicating a divergence-. *Period_square* is positive meaning that the convergence slows over time. The divergence is linear since *Period_square* is not significant. For the baseline treatment, all the regressors *Period* are not significant. Group contributions do not significantly converge to the threshold[23].

Table XI. Results from panel data regression explaining asymptotic group contributions for each treatment[a].

Regressors	T=15		T=30		T=60	
	Baseline	*Voluntary adhesion*	Baseline	*Voluntary adhesion*	*Baseline*	*Voluntary adhesion*
Intercept	12.80(*) (2.30)	19.64 (*) (17.05)	22.00(*) (7.45)	30.15(*) (21.39)	29.64(*) (2.63)	27.56 (*) (2,79)
Period_inverse	15.49(**) (2.64)	15,11 (*) (4.18)	13.01(**) (2.07)	23.09 (*) (3.89)	--	12.87(***) (1,74)
Log likelihood	6.5%[c]	-662	-564	-491	6.2%[c]	4.1%
Number of observation	150	200	150	125	100	100
Number of groups	6	8	6	5	4	4
Time periods	25	25	25	25	25	25

(*): significant at 1% level ; (**) : significant at 5% level ; (***) : significant at 10% level; -- non significant ; (a) : T-statistics are in parentheses (b) $G_{jt} = G_{\infty} + G_{0^*}\left(\frac{1}{t}\right) + u_j + \varepsilon_{jt}$ where j=1,2,..,J and t=1,2,..,25 ; (c) R2 overall GLS regressions; Regressions are corrected for heteroskedasticity and autocorrelation.

23 We run the same convergence analysis toward 0 (the Pareto dominated Nash equilibrium) for the high threshold. We find that in both treatments, convergence toward 0 is significant for the high threshold. This is consistent with the divergence from the threshold pointed out in Table 11.

Table XIII. Results from panel data regression explaining threshold convergence for each treatment [(a)].

Regressors	T=15		T=30		T=60	
	Baseline	*Voluntary adhesion*	Baseline	*Voluntary adhesion*	*Baseline*	*Voluntary adhesion*
Intercept	--	580.13 (*) (5.08)	234.73(***) (1.95)	281.37(*) (2.97)	709.14(**) (2.07)	--
Period	--	-59.52 (*) (-3.12)	--	-46.49 (*) (-2.86)	--	282.19(**) (2.10)
Period square	--	1.67 (**) (2.40)	1.62 (**) (2,11)	2.19 (*) (3.68)	--	-7.95(***) (-1.68)
Log likelihood	--	-1349	-1024	-713	-1487	-764
Number of observation	150	200	150	125	100	100
Number of groups	6	8	6	5	4	4
Time periods	25	25	25	25	25	25

(*): significant at 1% level; (**): significant at 5% level; (***): significant at 10% level; -- non significant; (a): T-statistics are in parentheses ; Regressions are corrected for heteroskedasticity and autocorrelation.

Discussion

We aim in this section to support that the reduction of the strategic uncertainty by voluntary adhesion is the origin of the higher effective results observed in the voluntary adhesion treatment.

Our experiment reveals that voluntary adhesion improves success of provision, group contributions and welfare in the low and the medium threshold. However, in the high threshold, there is no difference between the baseline and the voluntary adhesion treatment. Conjecture 3 states that when all subjects of the group decide to adhere to the club i.e. 4 tokens contributed, subjects are guaranteed that at least 26.66% of the Nash equilibrium will be provided in the low threshold, 13.33% in the medium threshold and 6.66% in the high threshold. As a consequence, it is in the lowest threshold that the voluntary adhesion reduces the maximum strategic uncertainty. This is consistent with our findings: The most effective results are observed first with the low threshold, then with the medium threshold and finally with the high threshold.

To support our hypothesis we ran another experiment where we stressed the reduction of the strategic uncertainty: we imposed a minimum contribution level (10 tokens) to benefit of the club good in the high threshold setting (Recall in the high threshold the baseline and the voluntary adhesion get the same results). Now, subjects need to add “only” 5 tokens to reach the symmetrical equilibrium whereas they previously needed 14 tokens. The same experimental design is replicated. Figure 5 depicts the average group contributions over time. Clearly, a visual inspection shows that voluntary adhesion with a minimum level of 10 tokens increases the level of group contributions. We perform the same panel data regression as previously to examine group contributions, success of provision and welfare. The output is reported in the Table XIII. *Voluntary adhesion* is positive and significant confirming statistically the visual inspection of the figure. The voluntary adhesion treatment does increase the group contributions, the success of provision in the high threshold. Hence, manipulating the minimum contribution parameter permits us to vary the strategic level of uncertainty of the game and to support our hypothesis.

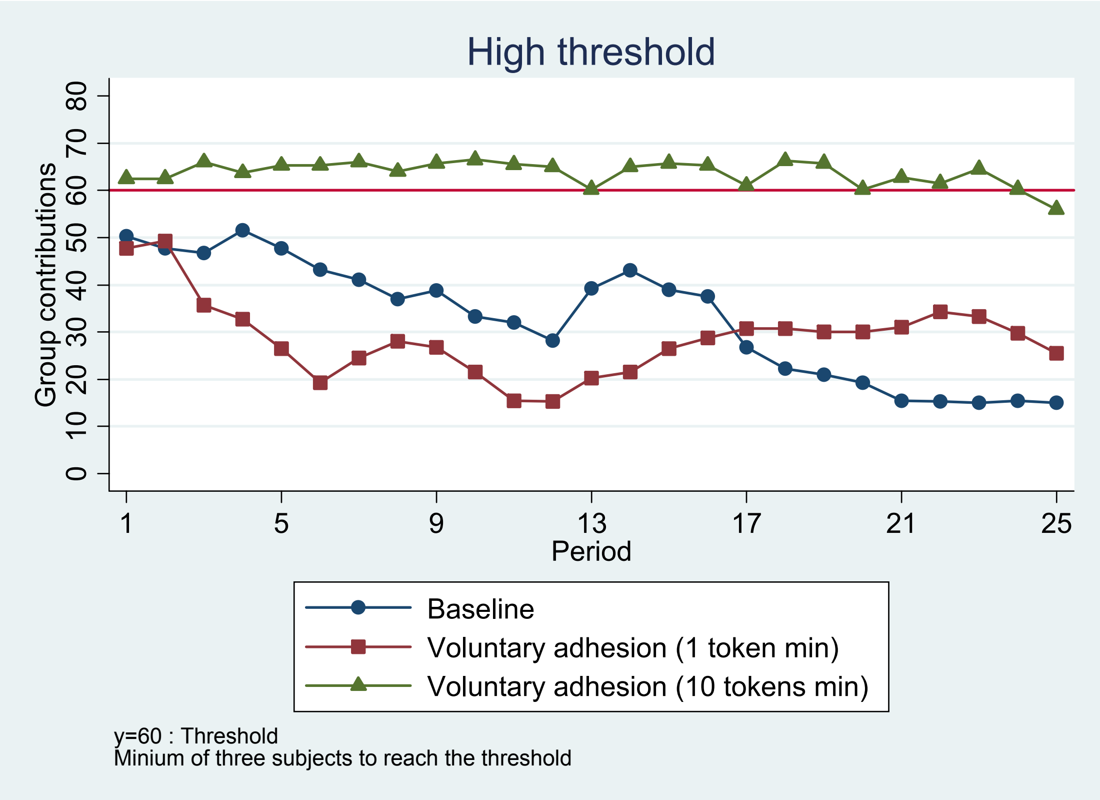

Figure 5. Average group contributions (T=60).

Table XIII. Results from panel data regressions explaining group contributions, success of provision and welfare for the high threshold (with minimum contribution) [(a)].

Regressors	Group contributions	Success of provision [(b)]	Welfare
Intercept	35.42 (*)	--	22.05 (*)
	(9.22)		(33.29)
Voluntary adhesion [(c)]	35.21 (*)	2.06 (*)	10.73 (*)
	(9.22)	(6.06)	(16.57)
Log likelihood	-652	-111	- 2965
Number of observation	200	200	200
Number of groups	8	8	8
Time periods	25	25	25

(*): Significant at 1% level; (**): significant at 5% level; (***): significant at 10% level; -- non significant; (a): T-statistics are in parentheses (b): Logit regression ; (c) dummy variable taking value 1 for the voluntary adhesion treatment. ; Regressions are corrected for heteroskedasticity and autocorrelation.

Conclusion

Club goods are characterized by voluntarism. An individual has the option to exclude himself from the provision of the club. Club goods are also characterized by their size. It fails to exist when there are not enough members or contributions, and, above this critical size, the club can improve its services or capacity. In this work, we investigate voluntary adhesion through the size issue by introducing a step-level mechanism. Our setting permits us to examine voluntary adhesion within two coordination games. We compare three levels of threshold, each time with and without voluntary adhesion.

Our experiment reveals that voluntary adhesion significantly increases group contributions, success of provision and welfare (except for the high threshold). Besides, our findings are consistent with the theoretical prediction; voluntary adhesion does increase the number of contributors. The use of step-level goods raises the additional issue of "cheap riding." –*i.e.* the implicit cost-sharing rule in reaching the provision point-. Our experiment shows that voluntary adhesion reduces cheap riding; while in the baseline treatment a few generous subjects contribute the bulk of the group contributions, in the voluntary adhesion treatment the effort to provide the threshold is more fairly distributed among the subjects. Finally, the experiment reveals that group contributions sustain longer in time in the voluntary adhesion treatment than in the baseline treatment. In particular, group contributions in the voluntary adhesion treatment of the medium threshold converge to the Nash equilibrium.

A possible explanation to our result is the decrease of the strategic uncertainty by voluntary adhesion. Voluntary adhesion guarantees the achievement of a percentage of the Nash equilibrium when members decide to adhere to the club. This percentage is maximal when the threshold is low (26.66% of the provision of the Nash equilibrium). The most effective results are observed for this setting. Imposing a minimum level of contribution to stress the reduction of the strategic uncertainty (66.66% of the provision of the Nash equilibrium) confirms our hypothesis. It raises the success rate of provision in the high threshold from 30.0% to 83.0%. Voluntary adhesion is an incentive to decrease the coordination failure.

References

CORNES R., SANDLER T., 1996. The theory of externalities, public goods, and club goods: Cambridge University Press New York.

ISAAC R. M., SCHMIDTZ D., WALKER J.M., 1989. "The assurance problem in a laboratory market." Public Choice, 62:3, p. 217-36.

MARKS M., CROSON R., 1998. Alternative rebate rules in the provision of a threshold public good: An experimental investigation. Journal of Public Economics, 67: 2, 195-220.

RONDEAU D., POE G.L., SCHULZE W.D., 2005. VCM or PPM? A comparison of the performance of two voluntary public goods mechanisms. Journal of Public Economics, 89:8, p. 1581-92.

ROSE S.K., CLARK J., POE G.L., RONDEAU D., SCHULZE W.D., 2002. "The private provision of public goods: tests of a provision point mechanism for funding green power programs." Resource and Energy Economics, 24: 1/2, p. 131-55.

BALTAGI B. H., 1995, Econometric analysis of panel data. Wiley New York.

BOUGHERARA D., DENANT-BOÈMONT L., MASCLET D., 2007, Creating vs. Maintaining Threshold Public Goods in Conservation Contracts. INRA Rennes.

CADSBY C.B., MAYNES E., 1999. Voluntary Provision of Threshold Public Goods with Continuous Contributions: Experimental Evidence. Journal of Public Economics, 71(1): 53-73.

CAMERA G., NOUSSAIR C., TUCKER S., 2003. Rate-Of-Return Dominance and Efficiency in an Experimental Economy. Economic Theory, 22: 629-660.

CORNES R., SANDLER T., 1996, The theory of externalities, public goods, and club goods. Cambridge University Press New York.

CROSON R., MARKS M., 2001. The effect of recommended contributions in the voluntary provision of public goods. Economic Inquiry, 39 (2): 238-249.

CROSON R.T.A., FATAS E., NEUGEBAUER T., 2006, Excludability and Contribution: A Laboratory Study in Team Production. mimeo.

CROSON R.T.A., MARKS M.,B., 2000. Step returns in threshold public goods: A meta-and experimental analysis. Experimental Economics, 2 (3), 239-259.

DAWES R. M., ORBELL J. M., SIMMONS R. T., VAN DE KRAGT A.J.C., 1986. Organizing Groups for Collective Action. The American Political Science Review, 80 (4): 1171-1185.

FISCHBACHER U., 2007. z-Tree: Zurich toolbox for ready-made economic experiments. Experimental Economics, 10(2): 171-178.

GAILMARD S., PALFREY T.R., 2005. An Experimental Comparison of Collective Choice Procedures for Excludable Public Goods. Journal of Public Economics, 89(8): 1361-1398.

GARY C., CHUN-LEI Y., 2006, Exit, Exclusion, and Mergers: Endogenous Group Formation and Public Goods Provision. University of California Santa Barbara.

GREENE W.H., 2003, Econometric Analysis Prentice Hall, New Jersey.

GUNNTHORSDOTTIR A., HOUSER D., MCCABE K., AMEDEN H., 2000. Excluding free-riders improves reciprocity and promotes the private provision of public goods, Working Paper, University of Arizona, Tucson.

ISAAC R. M., SCHMIDTZ D., WALKER J.M., 1989. The assurance problem in a laboratory market. Public Choice, 62 (3): 217-236.

KOCHER M., SUTTER M., WALDNER V., 2005. Exclusion from public goods as an incentive system. An experimental examination of different institutions. University Innsbruck. Working paper.

LEVATI M.V., SUTTER M., VAN DER HEIJDEN E., 2007. Leading by Example in a Public Goods Experiment with Heterogeneity and Incomplete Information. Journal of Conflict Resolution, 51 (5): 793.

LIST J.A., RONDEAU D., 2003. The impact of challenge gifts on charitable giving: an experimental investigation. Economics Letters, 79 (2): 153-159.

MARGREITER M., 2004. Just for the money? Exclusion in the Commons-Experimental Evidence. University of Innsbruck - Institute of Public Economics.

MARKS M., CROSON R., 1998. Alternative rebate rules in the provision of a threshold public good: An experimental investigation. Journal of Public Economics, 67(2): 195-220.

NG Y.K., 1973. The Economic Theory of Clubs: Pareto Optimality Conditions. Economica, 40 (3): 291-298.

RAPOPORT A., SULEIMAN R., 1993. Incremental contribution in step-level public goods games with asymmetric players. Organizational behavior and human decision processes, 55 (2): 171-194.

RONDEAU D., POE G.L., SCHULZE W.D., 2005. VCM or PPM? A comparison of the performance of two voluntary public goods mechanisms. Journal of Public Economics, 89 (8): 1581-1592.

ROSE S.K., CLARK J., POE G.L., RONDEAU D., SCHULZE W.D., 2002. The private provision of public goods: tests of a provision point mechanism for funding green power programs. Resource and Energy Economics, 24 (1/2): 131-155.

SANDLER T., TSCHIRHART J., 1997. Club theory: Thirty years later. Public Choice, 93(3): 335-355.

SCHELLING T.C., 1978, Micromotives and macrobehavior. Norton, New Tork.

SEVESTRE P., 2002, Econométrie des données de panel. Dunod, Paris.

SULEIMAN R. RAPOPORT A., 1992. Provision of step-level public goods with continuous contribution. Journal of Behavioral Decision Making, 5, 133-153.

SWOPE K. J., 2002. An Experimental Investigation of Excludable Public Goods. Experimental Economics, 5(3): 209-222.

VAN HUYCK J.B., BATTALIO R.C., BEIL R.O., 1990. Tacit Coordination Games, Strategic Uncertainty, and Coordination Failure. American Economic Review, 80 (1): 234-248.